

Steps in solving heredity problems:

Monohybrid crosses

I. Both parents are heterozygous

The allele of brown eyes is inherited as an autosomal dominant allele. If both parents are heterozygous, what is the probability that they can have a child with blue eyes? With brown eyes?

1. Assign a symbol for each allele

A capital letter is used for a dominant allele and a small letter for recessive allele.

Use the symbol **A** for brown eyes and **a** for blue eyes.

allele	genotype	phenotype
A	AA, Aa	Brown eyes
a	aa	Blue eyes

2. Determine the genotype of each parent and indicate a mating

Because both parents are heterozygous, the male genotype is Aa, female genotype is also Aa.

3. Determine all the possible kinds of gametes each parent can produce

Because gametes are haploid, they can have only one allele instead of the two present in the diploid cell. As the male has both the brown-eyed allele and the blue-eyed allele, then a half of his gametes will contain the brown-eyed allele and the other half will contain the blue-eyed allele. Because the female has the same genotype, her gametes will be the same as his.

To solve genetic problems, a Punnet square is used.

Female gametes	T	t
Male gametes		
T		
t		

4. Determine all the gene combinations that can result when gametes copulate

To determine the possible combinations of alleles that could occur as a result of this mating, simply fill in each of the empty squares with the alleles that can be donated from each parent.

Female gametes	T	t
Male gametes		
T	TT	Tt
t	Tt	tt

5. Determine the phenotype of each possible gene combination

In this problem, three of the offsprings, TT, Tt and Tt, have brown eyes. One progeny, tt has blue eyes. Therefore, the answer to the problem is that the probability of having offspring with brown eyes is $\frac{3}{4}$ (75%) and with blue eyes is $\frac{1}{4}$ (25%).

All monohybrid problems can be solved using this method

II. One parent is heterozygous and the other is homozygous for a trait:

If one parent is heterozygous for eyes color and the other is homozygous for this trait, what is the probability that they will have a child with brown eyes? Blue eyes?

Step1: Use the symbol A – for brown eyes and a – for blue eyes.

allele	genotype	phenotype
A	AA, Aa	Brown eyes
a	aa	Blue eyes

Step 2: Aa x aa

Step3:

	a
A	
a	

Step4:

	a
A	Aa
a	aa

Step 5:

In this problem, $\frac{1}{2}$ (50%) of the progeny will have brown eyes and $\frac{1}{2}$ (50%) will have blue eyes.

A dihybrid cross

A dihybrid cross is study in which two pairs of alleles are followed from the parental generation to the offspring. This problem is solved in basically the same way as the monohybrid cross. The main difference is that in the dihybrid cross you are working with two different characteristics from each parent.

It is necessary to use Mendel's law of independent assortment when considering double-factor problems. Recall that according to this law, members of one allelic pair separate from each other independently of the members of other pairs of alleles. This happens during meiosis when the chromosomes segregate (Mendel's

law of independent assortment applies only if the two pairs of alleles are located on separate chromosomes).

Problem: In humans, the allele for free earlobes is dominant over the allele for attached earlobes. The allele for dark hair dominates over the allele for light hair. If both parents are heterozygous for earlobes and hair color, what types of offspring can they produce, and what is the probability for each type?

Step 1; Use the symbol:

E - free earlobes

e - attached earlobes

D - dark hair

d - light hair.

Genotype	Phenotype
EE, Ee	Free earlobes
ee	Attached earlobes
DD, Dd	Dark hair
dd	Light hair

Step 2: Determine the genotype for each parent and show a mating:

♀EeDd X ♂EeDd

Step 3: Determine all the possible gametes each parent can produce and write the symbols for the alleles in a Punnett square. Because there are two pairs of alleles in a double-factor cross, each gamete must contain one allele from each pair. Thus, each parent can produce four different kinds of gametes.

To determine the possible gene combinations in the gametes, select one allele from one of the pairs of alleles and match it with one allele from the other pair of the alleles. Then, match the second allele from the first pair of alleles with each of the alleles from the second pair. This may be done in a following way:

	♂	ED	Ed	eD	ed
♀	ED				
	Ed				
	eD				
	ed				

Step 4: Determine all the gene combinations that can result when these gametes unite. Fill in the Punnett square:

♂	♀	ED	Ed	eD	ed
	ED	EEDD	EEDd	EeDD	EeDd
	Ed	EEDd	EEdd	EeDd	Eedd
	eD	EeDD	EeDd	eeDD	eeDd
	ed	EeDd	Eedd	eeDd	eedd

Step 5: Determine the phenotype of each possible gene combination. In this problem there are 16 possible ways in which gametes can combine to produce an offspring. There are four possible phenotypes in this cross. They are represented in the following chart:

- E-D- (EEDD, EEDd, EeDd, EeDD) - free earlobes, dark hair
- E-dd (EEdd and EeDD) - free earlobes, light hair
- eeD- (eeDd and eeDD) - attached earlobes, dark hair
- eedd - attached earlobes, light hair

The probability of having a given phenotype is:

- 9/16 free earlobes, dark hair
- 3/16 free earlobes, light hair
- 3/16 attached earlobes, dark hair
- 1/16 attached earlobes, light hair

Codominance

Problem: If one parent is heterozygous for A blood group and the other is heterozygous for B blood group, what phenotype can their child have?

Step 1: I^A – A blood group, I^B – B blood group

In the ABO system, A and B show codominance when they are together in the same individual; but both are dominant over the O allele.

Genotype	Phenotype
$I^A I^A, I^A I^O$	A blood group
$I^B I^B, I^B I^O$	B blood group
$I^A I^B$	AB blood group

Step 2: $I^A I^O$ X $I^B I^O$

Step 3: Gametes:

	I^B	I^O
I^A		
I^O		

Step 4:

	I^B	I^O
I^A	$I^A I^B$	$I^A I^O$

I^0	$I^B I^0$	$I^0 I^0$
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Step 5: Thus, this cross results in four different phenotypes – 0, A, B, and AB blood groups.

1. Steps in solving heredity problems: **X-linked**

Problem: In humans the gene for normal color vision is dominant and the gene for color deficiency is recessive. Both genes are X-linked. People who are color blind are not really blind, but should more appropriately be described as having “color defective vision”. A male who has normal vision mates with a female who is heterozygous for normal color vision. What type of children can they have in terms of these traits, and what is the probability for each type?

Step 1: This condition is linked to the X chromosome, so it has become traditional to symbolize the allele as the superscript on the letter X. Because the Y chromosome does not contain a homologous allele, only the letter Y is used.

X^D – normal color vision

X^d – color deficient

Y – no gene present

Genotype	Phenotype
$X^D Y$	Male, normal color vision
$X^d Y$	Male, color deficient
$X^D X^D$	Female, normal color vision
$X^D X^d$	Female, normal color vision
$X^d X^d$	Female, color deficient

Step 2: Male's genotype - $X^D Y$ (normal color vision), female's genotype - $X^D X^d$ (normal color vision).



Steps 3, 4: The genotype of the gametes are listed in the Punnett square:

	X^D	X^d
X^D	$X^D X^D$	$X^D X^d$
Y	$X^D Y$	$X^d Y$

Step 5: The phenotype of the offspring are determined:

$X^D X^D$, $X^D X^d$ - daughters with normal color vision (100%)

$X^D Y$ - sons with normal color vision (50%)

$X^d Y$ - sons with color blindness (50%)